

99D-104

4.5 PSP Cover Sheet (Attach to the front of each proposal)

Proposal Title: Effects of Fire on Sediment Processes in Sierra Nevada Forested Watersheds Applicant
 Name: Jon E. Keeley and Claudette L. Moore Mailing Address: _____
USGS/BRD/WERC Sequoia and Kings Cyn Field Station Telephone: (559) 565-3170
47050 Generals Hwy., Three Rivers, CA 93271 Fax: (559) 565-3177
 Email: jon keeley@usgs.gov

Amount of funding requested: \$ 390,752.00 for 3 years

Indicate the Topic for which you are applying (check only one box).

- | | |
|---|---|
| <input type="checkbox"/> Fish Passage/Fish Screens | <input type="checkbox"/> Introduced Species |
| <input checked="" type="checkbox"/> Habitat Restoration | <input type="checkbox"/> Fish Management/Hatchery |
| <input type="checkbox"/> Local Watershed Stewardship | <input type="checkbox"/> Environmental Education |
| <input checked="" type="checkbox"/> Water Quality | |

Does the proposal address a specified Focused Action? yes no

What county or counties is the project located in? Tulare

Indicate the geographic area of your proposal (check only one box):

- | | |
|---|---|
| <input type="checkbox"/> Sacramento River Mainstem | <input type="checkbox"/> East Side Trib: _____ |
| <input type="checkbox"/> Sacramento Trib: _____ | <input type="checkbox"/> Suisun Marsh and Bay |
| <input type="checkbox"/> San Joaquin River Mainstem | <input type="checkbox"/> North Bay/South Bay: _____ |
| <input type="checkbox"/> San Joaquin Trib: _____ | <input type="checkbox"/> Landscape (entire Bay-Delta watershed) |
| <input type="checkbox"/> Delta: _____ | <input checked="" type="checkbox"/> Other: <u>Kaweah Basin</u> |

Indicate the primary species which the proposal addresses (check all that apply):

- | | |
|--|--|
| <input type="checkbox"/> San Joaquin and East-side Delta tributaries fall-run chinook salmon | <input type="checkbox"/> Spring-run chinook salmon |
| <input type="checkbox"/> Winter-run chinook salmon | <input type="checkbox"/> Fall-run chinook salmon |
| <input type="checkbox"/> Late-fall run chinook salmon | <input type="checkbox"/> Longfin smelt |
| <input type="checkbox"/> Delta smelt | <input type="checkbox"/> Steelhead trout |
| <input type="checkbox"/> Splittail | <input type="checkbox"/> Striped bass |
| <input type="checkbox"/> Green sturgeon | <input type="checkbox"/> All chinook species |
| <input type="checkbox"/> Migratory birds | <input type="checkbox"/> All anadromous salmonids |
| <input checked="" type="checkbox"/> Other: <u>Benthic biota</u> | |

Specify the ERP strategic objective and target (s) that the project addresses. Include page numbers from January 1999 version of ERP Volume I and II:

ERP I - nontidal perennial streams, pg. 83; sediment supply, pg. 28; fire, pg. 332
 ERP II - cottonwood creek, pg. 192; Yolo Basin, pg. 317

Indicate the type of applicant

(check only one box):

- | | |
|--|--|
| <input type="checkbox"/> State agency | <input checked="" type="checkbox"/> Federal agency |
| <input type="checkbox"/> Public/Non-profit joint venture | <input type="checkbox"/> Non-profit |
| <input type="checkbox"/> Local government/district | <input type="checkbox"/> Private party |
| <input type="checkbox"/> University | <input type="checkbox"/> Other: _____ |

Indicate the type of project (check only one box):

☐ Planning
☐ Monitoring
☒ Research

☐ Implementation
☐ Education

By signing below, the applicant declares the following:

- 1.) The truthfulness of all representations in their proposal;
- 2.) The individual signing the form is entitled to submit the application on behalf of the applicant (if the applicant is an entity or organization); and
- 3.) The person submitting the application has read and understood the conflict of interest and confidentiality discussion in the PSP (Section 2.4) and waives any and all rights to privacy and confidentiality of the proposal on behalf of the applicant, to the extent as provided in the Section.

Jon E. Keeley
Printed name of applicant

Jon E. Keeley
Signature of applicant

Effects of Fire on Sediment Processes in Sierra Nevada Forested Watersheds

**Proposal Submitted to CalFed
16 April 1999**

**Category Type 3: Federal Agency
Tax Status: Exempt**

**Jon E. Keeley and Claudette L. Moore
Sequoia and Kings Canyon Field Station
Biological Resources Division, USGS
47050 Generals Highway
Three Rivers, CA 93271-9651
(559) 565-3170
Fax 565-3177
jon_keeley@usgs.gov**

Executive Summary

The most profound anthropogenic changes to the structure and function of forest ecosystems of the Sierran national parks -- greater than both the effects of the preceding three millennia of climatic change, and of recent air pollution -- have been direct consequences of fire exclusion. Given that the Secretary of Interior has ordered more aggressive application of prescribed fire on Interior lands in the west, it is more important than ever that we understand the ecosystem consequences of fire and fire exclusion.

A pilot watershed study in Sequoia National Park revealed that reintroduction of fire had a vastly more profound influence on soil and stream chemistry, at least over the short term, than any changes in climate and air pollution over the preceding decade of measurements. In an attempt to better understand the effects of fire on Sierran watersheds, watershed research in the Park expanded to include two first order watershed sites in the East Fork drainage of the Kaweah River. The 21,000-ha East Fork watershed is slated to be burned, a block at a time, over the next several years as part of the Mineral King Risk Reduction Project, a nationally-significant effort to determine the cost-effectiveness and ecological consequence of applying fire at a landscape scale (funded by the National Interagency Fire Center). Coinciding with the start of the Mineral King Risk Reduction Project in 1995, the SEKI watershed program began its efforts to determine the effects of fire on stream chemistry, hydrology, and aquatic macro-invertebrate communities. The watershed efforts in the East Fork drainage are tightly coordinated with a much larger research and monitoring effort tied to the burn project (Caprio 1996).

While many aspects of post-fire effects on Sequoia National Park watersheds are currently being studied (vegetation structure and function and stream chemistry), changes in erosion rates and sediment transport remain an unstudied area of concern following fire (prescribed or wildfire). This has not previously been undertaken because sediment studies are labor intensive, expensive and problematic when compared to vegetation and stream chemistry studies. Also, the high degree of natural variability in erosion and sediment transport require that several watersheds be monitored to capture the range of that variability.

Thus, the goal of the research proposed here may be stated as follows: **We wish to build upon our long-term research base to determine and understand the effects of reintroducing fire on sediment transport and erosion in small Sierran watersheds.** This proposal outlines an experimental approach to determining some of the effects of fire on sediment transport and storage, and hillslope erosion in small (≤ 100 ha) Sierran watersheds.

Project Description

Proposed Scope of Work

The goal of the proposed project is to measure sediment transport and storage in streams and hillslope erosion in low order watersheds before and after reintroduction of fire to forested ecosystems on the western slope of the Sierra Nevada. In addition, we will also determine the relationship between turbidity and suspended sediment concentration in the study watersheds to determine if turbidity is an appropriate surrogate for such measurements. This relationship has been successfully established in some Pacific Northwest catchments providing more continuous information on suspended sediment movement (Barber 1996, Lewis and Eads 1996).

Six small (≤ 100 ha) catchments will be instrumented with data loggers and pressure transducers to monitor discharge over 3 years. Suspended sediment concentration values will be determined for each stream using point samples collected with automated samplers. Depth-integrated samples collected with a DH-48 hand-held sediment sampler will be used to develop a cross-section coefficient, which is necessary for extrapolating the point sample value to the entire stream cross section (Edwards and Glysson 1988).

Three pools in each stream will be surveyed and sampled to determine sediment storage and movement over time. Pebble counts and excavated core samples will be used to determine particle size distribution, and detailed cross-sectional pool surveys will be used to determine changes in storage volume following fire. Erosion bridges will be used to evaluate hillslope erosion over time.

Continuous turbidity measurements will be made in three of the six watersheds to determine if a valid relationship exists between turbidity and suspended sediment concentration. Turbidity measurements provide two potentially useful relationships with sediment. First, studies have shown that sediment/turbidity regressions are more sensitive, and therefore, more representative of sediment transport than sediment/discharge relationships. Also, if a valid sediment/turbidity relationship is established, continuous turbidity measures will capture sediment pulses from events such as stream bank and/or hillslope failure that would otherwise go unsampled (Lewis and Eads 1996).

Phase 1

Select sites, construct and install equipment, test monitoring equipment and data loggers, fine tune programming, collect preliminary discharge and sediment data, work out site bugs, train technicians on data logger programming, downloading and troubleshooting. This phase of the project will take approximately four months.

Task 1a. Reconnaissance and site selection - Visit potential watershed sites in the Middle Fork and East Fork included in the five year prescribed fire plan for suitability. Potential sites will be identified from the prescribed fire map units, and then an onsite visit will be made. Criteria for site suitability will include accessibility, fire history, size (all sites will be ≤ 100

ha), feasibility (labor required to install flume and equipment housing), and presence or absence of other research (the presence of vegetation and/or water chemistry work will add value to the results of the sediment project).

Task 1b. Conduct preliminary discharge measurements. These measurements will be required to determine the proper size Parshall flume to install. A tracer method will be used to conduct three to five measurements (Kilpatrick and Cobb 1985).

Task 1c. Construct monitoring station and install equipment. Construction and installation will require six to eight people for approximately eight weeks (four weeks at each site). Site setup involves building a platform for the flume and stilling well, building the wing walls at the flume approach, leveling the stream bed, and constructing housing for the automated samplers and data loggers. In addition, equipment housing will need to be constructed and installed at the sites already in place. The time required will vary depending on how equipment is delivered to the site (options include packstock, helicopter and technicians).

Task 1d. Install data loggers and transducers at each site. Data loggers will be programmed, and sensors will be mounted and secured in the stream. Transducers will be housed in a stilling well. The automated sampler tubing will be mounted at 6/10 of the stream depth in the direct stream current and oriented downstream to prevent clogging.

Task 1e. Install and test automated samplers, begin testing turbidity probes, and compare HD-48 suspended sediment measurements. Each site will require field testing to ensure that the pumping instructions in the sampler are adequate to meet the head requirements between the sample bottle and the intake tube. Collect preliminary automated point samples at each site and compare with HD-48 integrated samples to establish a cross-section coefficient. This task should include some storm sampling. Continual turbidity measurements will also be collected and compared with the point and integrated suspended sediment values. The turbidity measurements will be compared and evaluated as the project continues as a means of collecting surrogate suspended sediment data.

Phase 2

Sampling and data collection is expected to take approximately two years.

Task 2a. Begin sampling and data collection. Develop sampling interval based on wet and dry season. Each station will be visited at least monthly to collect discharge and turbidity data and to check site for problems. Sediment collection will be based on the prediction of storms during the wet season. Sediment collection will also be collected during snowmelt. These periods will require more intensive sampling. Low flow samples will be collected as determined by the preliminary findings.

Task 2b. Select three pools in each stream to monitor changes in sediment storage and deposition. Pools will be sampled for particle size using the pebble count method (Wolman 1954). Subsurface bed sediments will be collected using the modified excavated core sampler (Chan 1999). Approximately 200 sediment cores will be collected during the course of the

project (3 samples from each pool at six stations measured four times during the study). The pools will also be surveyed to map changes in storage capacity. Pools will be surveyed in the fall prior to the onset of the wet season, and in the late spring/early summer following snow melt runoff.

Task 2c. Establish and monitor hill slope erosion plots. Prior to any burning, hill slope erosion sites will be selected to monitor post-fire soil movement. Brown's transects will be used to determine litter and duff volume at each site and erosion bridges will be installed (ref). Erosion bridges will be marked by two pieces of rebar at either end of the plot. Soil samples will be collected and analyzed for particle size and soil class. Sites will be selected based on their potential for erosion and will be ranked as having high, medium or low potential for erosion following fire. Ranking will be based on slope and soils information derived from the soil samples.

Task 2d. Establish and maintain data sets. Verify data, develop regression relations between sediment and discharge, and sediment and turbidity. Review preliminary findings.

Phase 3

Analyze data, prepare final report and publications, and make recommendations for future sediment work. This phase of the project is expected to take six months.

Task 3a. Analyze sediment cores. The cores will be sent to another USGS lab for drying and analysis. Particle size distribution and percentage of total will be determined by sieving samples.

Task 3b. Analyze sediment data, develop regressions with turbidity and discharge.

Task 3c. Write final report and publications.

Project Management

The project will be managed by the Sequoia-Kings Canyon Field Station Leader. Quarterly reports will be drafted by the Watershed Ecologist, and reviewed and finalized by the Station Leader. All analysis will be conducted on site, except for sediment cores, which will be analyzed by a USGS Water Resources Division lab.

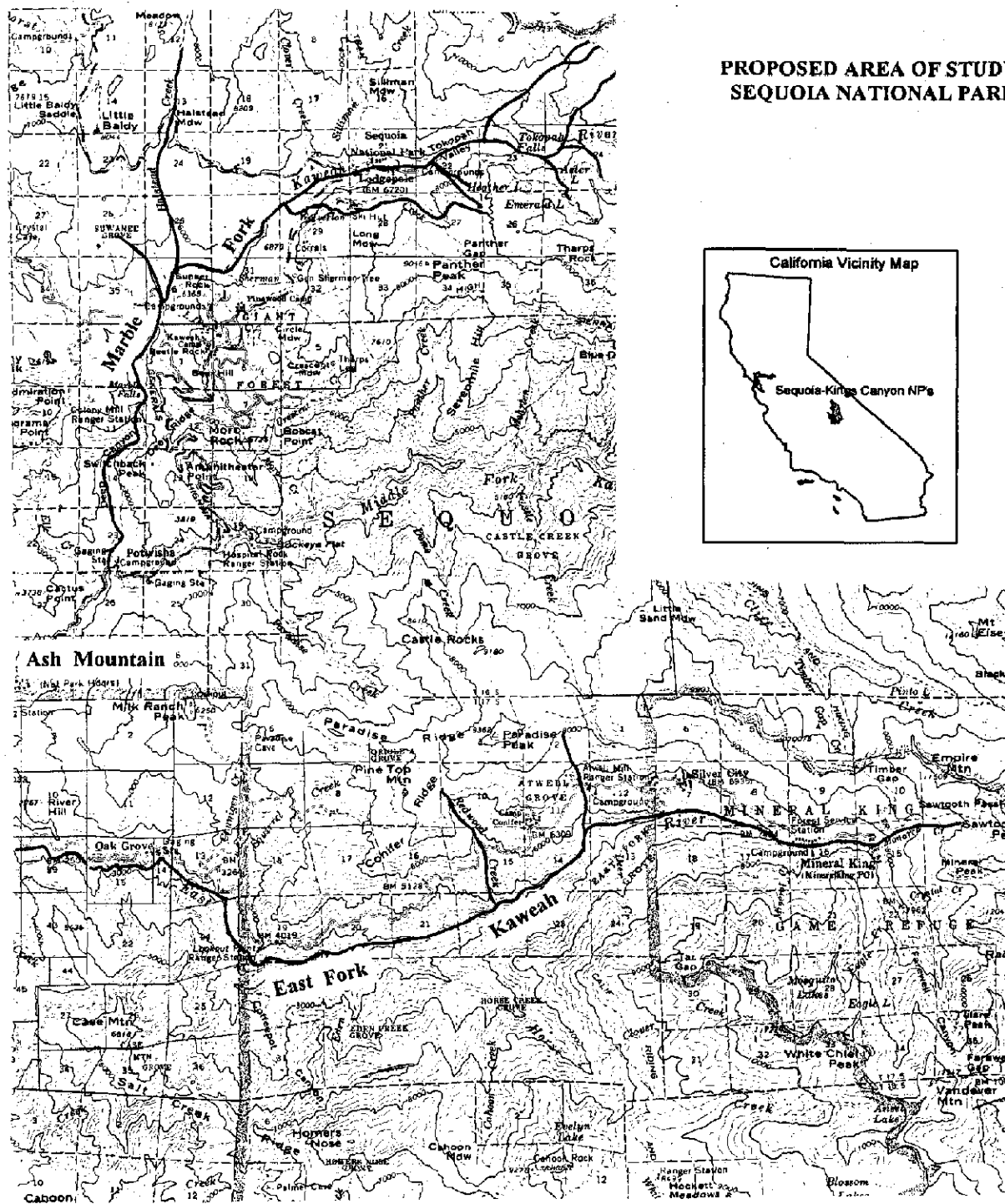
Partial Funding Strategy

The proposed work schedule is based on a three year project to monitor six watersheds. If funding is limited, we would conduct the project with four sites that are presently monitored for water quality as part of the long-term watershed monitoring program conducted by USGS Biological Resources Division at the Sequoia-Kings Canyon Field Station. This would eliminate much of the time and cost involved in Phase 1 (see above), and would also reduce the number of staff required to complete the project. Tasks 1a and 1b would be eliminated. Tasks 1c and 1d would be reduced to working at established sites.

Watershed Locations

The proposed sediment project will be conducted in Sequoia National Park (southern Sierra Nevada), located in Tulare County. The East Fork Kaweah and Marble Fork Kaweah River Basins will be the primary areas of study (Figure 1). These watersheds are ultimately part of the Sacramento-San Joaquin Watershed and are representative of moderate sized drainage basins on the west side of the Sierra Nevada (Moyle and Randall 1996). These watersheds are part of a long-term monitoring program that has focused on atmospheric deposition and stream chemistry/discharge studies (Parsons and Graber 1985, Herrmann and Stottlemeyer 1991). They encompass a wide elevation range (520m to 3960m) and diverse vegetation including chaparral, mixed-conifer and subalpine communities. Six first or second order watersheds (<100 ha) will be selected in mixed-conifer and chaparral areas. Site selection will be representative of the topographic and physical diversity within these small catchments, and the various stages of fire reintroduction, including areas that have been burned within the last ten years and areas that are scheduled to burn within the next five years. Four of the proposed sites are presently equipped with data loggers that record discharge, and are part of a long-term watershed monitoring program. Two additional sites will be selected based on accessibility and feasibility for equipment installation. All selected sites will be accessible year round. Table 1 summarizes the physical features and watershed research in the four catchments that are presently monitored and this monitoring will continue under our original funding. The present proposal to CALFED is for the purpose of adding a new component, sediment transport, to our ongoing water quality studies.

PROPOSED AREA OF STUDY SEQUOIA NATIONAL PARK



Scale 1:125,000

Figure 1. Map of proposed study area in Sequoia National Park. Copied from USGS map of Sequoia and Kings Canyon National Parks.

Table 1. Site descriptions, baseline data, proposed project and funding sources for watershed sites in Sequoia NP.

Description				Baseline Data					
Site	Elevation (m)	Catchment size (ha)	Vegetation type	Prescribed fire date	Discharge	Stream Chemistry	Meteorology	Precipitation Chemistry	Aquatic Invertebrates
Middle Fork									
Tharp's Cr.	2067	13.1	Sequoia/ Mixed- Conifer	1990	'83 - present/A	'83 - present/A	'83 - present/A	'83 - present/A	nd
Log Cr.	2067	48.9	Sequoia/ Mixed- Conifer	control	'83 - present/A	'83 - present/A	'83 - present/A	'83 - present/A	nd
East Fork									
Trauger's Cr.	1400	106	Chaparral	1999	'96 - present/A	'95 - present/A	'95 - present/A	nd/	'96 - '97
Deadwood Cr.	2000	100	Sequoia/ Mixed- Conifer	1999	'96 - present/A	'95 - present/A	'95 - present/A	nd/	'96 - '97

* East Fork Watershed ranges from chaparral to alpine vegetation.

nd - no data

na - not applicable

Funding Sources: A - USGS/BRD & NPS funds, B - potential CalFed funds, C - Not funded/ seeking other sources

Table 1. (con.)

Baseline Data (con.)				Fire Effects			
Site	Stream Morphology	Sediment Transport	Soils Classification	£Soils Chemistry	Fire Effects on Vegetation	Fire Effects on Aquatic Invertebrates	Fire Effects on Stream Morphology
Middle Fork							
Tharp's Cr.	nd	nd/B	'83 - '87	'83 - '93	'83 - present/A	nd	nd
Log Cr.	nd	nd/B	'83 - '87	'83 - '93	'83 - present/A	nd	nd
East Fork							
Trauger's Cr.	'96	nd/B	nd/C	nd/C	nd/C	nd/C	nd/C
Deadwood Cr.	'96	nd/B	nd/C	nd/C	nd/C	nd/C	nd/C

nd - no data

na - not applicable

Funding Sources: A - USGS/BRD & NPS funds, B - potential CalFed funds, C - Not funded/ seeking other sources

£ Collaboration in progress with Penn. State University.

Ecological / Biological Benefits

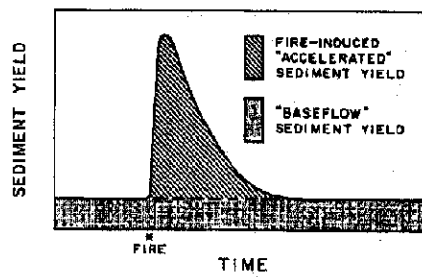
In the western United States, a century of fire exclusion has led to changes in the health, composition, structure, and function of forest ecosystems and has increased wildfire threats to both humans and natural resources (McKelvey et al. 1996). Consequently, the Secretaries of both Interior and Agriculture have promised Congress and the American people that their bureaus will take immediate and aggressive steps to alleviate these problems by more actively treating accumulated fuels and thickened stands. In western national parks, this means that prescribed fire will be applied more aggressively at landscape scales.

The National Interagency Fire Center has launched a major effort to assess the operational requirements, cost effectiveness, and ecological consequences of using large-scale prescribed burning as a tool in wildland management. A flagship of this effort is a landscape-scale burn program — the Mineral King Risk Reduction Project — in the watershed of the East Fork of the Kaweah River, Sequoia and Kings Canyon National Parks. A contiguous area of about 21,000 ha will be prescribed burned over a period of less than a decade, and represents a landscape scale burn program unprecedented in the western national parks. The five year burn plan for Sequoia-Kings Canyon includes additional area in the Marble Fork of the Kaweah River. Selected burned watersheds in these two drainages will be part of a 10 site national network proposed for study of the biological impacts of prescription burning under the USDA/USDI Joint Fire Science Program.

Many aspects of post-fire effects on Sequoia National Park watersheds are currently being studied, including changes in vegetation structure and function, and mortality and recruitment rates, as well as stream chemistry and discharge rates. However, changes in erosion rates and sediment transport remain an unstudied area of concern following fire (prescribed or wildfire). This has not previously been undertaken because sediment studies are labor intensive, expensive and problematic when compared to vegetation and stream chemistry studies. Also, the high degree of natural variability in erosion and sediment transport require that several watersheds be monitored to capture the range of that variability.

Excessive sediment delivery into streams was identified as one of the most critical water quality problems in Sierra Nevada streams (Menning et al. 1996). Such perturbations potentially may affect fish invasions as well as the native fauna (Moyle and Light 1996). Causes include road construction, logging, grazing and fire. Increases in sediment yield following fire can be one of the of the most significant impacts of fire (Figure 2). Given that the Secretary of Interior has ordered more aggressive application of prescribed fire on Interior lands in the west, it is more important than ever that we begin to address the consequences of fire and fire exclusion on sediment delivery and hillslope erosion rates. This is critical not only because of very limited information on sediment yields following fire in forested watersheds (Swanson 1981) -- particularly steep Sierran watersheds -- but there is no prediction as to the potential impacts of restoring fires to forests that have had nearly a century of fire exclusion. While there are many agencies concerned with fire behavior and vegetation impacts resulting from burning forests with 100 years of accumulated fuels, no one is addressing potential impacts on downstream values, in particular sediment transport.

Figure 2. Schematic view of changes in sediment yield during period of watershed response to fire (from Swanson 1981).



Disturbance such as fire can result in dramatic increases in peak and total discharge. Pre- and post-fire hydrologic measurements will allow us to quantify the magnitude of those changes in the study catchments. Continuous discharge records before and after fire will identify any shifts in the magnitude and duration of high flow, as well as reveal changes in base flow. In addition, discharge records are essential for determining mass balances of solutes, necessary for determining the effects of air pollution and climatic change on southern Sierran catchments. Increases in erosion and sediment transport are among the most dramatic and potentially deleterious water quality responses associated with fire (Tiedemann et al. 1979).

Research Objectives

1. How do topography and geomorphology influence sediment transport and hillslope erosion in small catchments following fire?

Research following the Yellowstone fires of 1988 indicated that low order streams are more affected by fire because small watersheds tend to experience fire over a larger percent of the catchment. However, the magnitude and quality of those effects are also influenced by stream gradient, aspect, and riparian area (Minshall and Brock 1991, Minshall and Robinson 1992). The 1990 prescribed fire in Tharp's Creek Watershed (Sequoia National Park) examined the effects on solution chemistry of a single fire on a single small (<25 ha), low gradient watershed (Chorover et al. 1994, Williams and Melack 1997). Expanding this research to include monitoring sediment transport in small catchments under the various stages of fire reintroduction will allow us to characterize a range of sediment transport responses to fire. We will compare post-fire responses in sediment transport in mixed-conifer catchments.

2. How do post-fire precipitation patterns affect hillslope erosion and sediment movement in small catchments?

The Sierra snowpack is characterized as "warm", the ground does not freeze and snowmelt can occur throughout the winter (Smith 1974). Sierran precipitation patterns (frequency, duration and timing) and type (snow or rain) vary from year to year. In the last twenty years Sequoia NP has experienced two of the most severe El Niño winters on record, a seven year drought, and several "Pineapple Express" events, which resulted in rain on snow events and substantial flooding. Precipitation pattern and type greatly influence the outcome of post-fire hillslope erosion and sediment movement through

these small streams. Heavy rain following fire may result in severe hillslope erosion and sediment delivery, whereas a winter snowpack will likely mitigate hillslope erosion by incrementally mobilizing sediment throughout the snowmelt period. In March 1991, Tharp's catchment, which was burned in fall 1990, received over two inches of rain in 36 hours resulting in a substantial pulse of sediment delivery to the stream. How does hillslope erosion vary following fire? Is one physical feature (slope, aspect, soil, etc.) more dominated in post-fire erosion? Does fire behavior affect erosion? Is turbidity an adequate surrogate for SSC values?

3. How does the timing of fire (late vs early season burning) affect sediment transport?

Are there burning regimes that could be used to reintroduce fire to these ecosystems that have less impact on sediment transport? Sediment plays an important role in stream function, by regulating the sequence of riffles and pools in a stream channel and by acting as substrate for biota and chemical exchange. (Goldman and Horne 1983, Sidle 1988). When fire is restored after a century of exclusion, sediment flux from uplands to stream are expected to be large. This flux is further enhanced by increased peak and total discharges due to decreases in transpiration (through loss of vegetation) (Minshall and Brock 1991, Robichaud and Waldrop 1994). Erosion and increased sediment transport are some of the most dramatic and important water quality responses associated with fire (Tiedemann et al. 1979). Are changes in sediment transport correlated with seasonal burning? How is sediment storage in small forested catchments affected following fire?

Linkages

Sequoia National Park established a long-term watershed program in the early 1980's to evaluate the effects of disturbance (air pollution, global climate change and fire) on stream chemistry and discharge (Parsons and Graber 1985, Herrmann and Stottlemeyer 1991). Presently, four streams are gauged in two of the major drainage basins in the park: the Middle Fork Kaweah and the East Fork Kaweah. These catchments are included in areas that are scheduled to be burned in the next five years, or have been burned previously.

This project will greatly benefit from long-term watershed monitoring and data collection efforts that have been in place in Sequoia NP since the early 1980's. Extensive records exist for precipitation depth and chemistry, meteorology, stream chemistry, and discharge. Discharge measurements in the four sites currently monitored will continue to be funded by project money appropriated through means other than CalFed. CalFed funds will be used to purchase the necessary equipment for sediment work and establish the two new sites. This project will concentrate on collecting data in four areas: sediment transport, turbidity, hillslope erosion, and stream discharge. Precipitation records will be obtained from the Sequoia field station.

Systemwide Ecosystem Benefits

The mission of the CALFED Bay-Delta Program is to develop a long-term comprehensive plan that will restore ecological health. One conclusion of the SNEP Report (SNEP 1996) was that

"Rivers and their watersheds extend beyond the geologic edges of the Sierra Nevada to their final destination in ocean, valley, or basin. Fish and other aquatic life have evolved to occupy habitat zones within certain elevations along the rivers, but they do not have sharp or readily defined downstream or upstream boundaries."

Sediment transport and deposition affect habitat quality and the landscape scale reintroduction of fire to these forested ecosystems, following 100 years of fire exclusion, has the potential for altering these ecosystem processes.

Compatibility with Non-Ecosystem Objectives

There are no conflicts with other CALFED objectives and there are potential benefits for understanding issues of water quality and water supply reliability.

Benefits to third parties include increasing predictive power of agencies, such as the Army Corp of Engineers, concerned with issues of reservoir holding capacity. Currently this is of extreme importance for watersheds like the Kaweah, and in the future global change environment, which incorporates landscape scale prescription burning, it will be of importance to watersheds throughout the front range of the Sierra Nevada.

Technical Feasibility and Timing

Suspended sediment methods. Methods to measure suspended sediment concentration include automated samplers, which yield a point suspended sediment concentration value and depth-integrated samplers (hand held type). Automated samplers enable the user to program the sampler to turn on and off at a preset time, increasing the potential for measuring for the duration of a storm event. Disadvantages of the automated sampler include possible clogging at the intake and some loss in accuracy. In addition, a cross-section coefficient is necessary to extrapolate point values to the entire stream cross section. Due to the remoteness of the study sites, the benefits of automated samplers outweigh the disadvantages for this project. These samplers will enable us to sample a wide range of precipitation and runoff events. Accuracy can be improved by selecting an automated sampler that has a high rating for sediment sampling (Edwards and Glysson 1988). To obtain the best possible results, some in-stream modifications may be necessary, and will be determined during Phase 1 of the project.

Hillslope erosion methods. There are several methods used to evaluate hillslope erosion: erosion pins, erosion bridges and sediment troughs. Erosion bridges were selected for this project because they are economical and easy to maintain, and highly accurate.

Potential problems. A series of drought years will result in a decrease in the magnitude of the annual hydrograph flux. Low precipitation and a dampened hydrograph may reduce some of the variation we expect to see in sediment movement and hillslope erosion in small catchments following fire.

Implementation. This project would add a component to on-going studies of water quality and stream discharge that have been in place for over 15 years. All necessary compliance documents for on-going and proposed portions of this study are up to date.

Monitoring and Data Collection Methodology

Sediment Transport. Sites will be equipped with automated samplers, programmed to collect suspended sediment samples based on hydrograph changes. Four automated samplers will be shared

between six sites. Samples will include storm events, snowmelt runoff and base flow periods. Sampling frequency will be season dependent. Base flow periods will be sampled monthly. Storm event sampling will vary based on the type of precipitation. We will try to capture a minimum of three rain events at each site. Intensive sampling will occur during the snowmelt runoff period, and may include sampling each site daily for a week or more. These point samples will be calibrated with a hand-held sampler (DH-48). Pools will be surveyed to monitor changes in pool morphology and sediment storage capacity. Particle size will be determined using pebble counts and excavated core samples.

Turbidity Measurements. Turbidity sensors will be installed at three sites. These meters will be programmed to record at 15 minute intervals to correspond with discharge measurements. This experimental data will enable us to determine if turbidity measurements are a good surrogate for suspend sediments in small Sierran mixed-conifer catchments.

Hillslope Erosion. Erosion bridges will be used to evaluate hillslope erosion following fire. A series of plots will be established, varying in slope, aspect and vegetation cover. The number of plots will depend on the overall variability within the study catchment. The erosion plots will be measured bi-weekly once bare ground is exposed in the plot. This will continue until the plots have dried out for the season, at which time monthly sampling will occur. This will vary by site and year. Fall sampling frequency will depend on the type and pattern of early season precipitation.

Hydrology. All of the study watersheds will be equipped with data loggers and/or chart recorders that record 15 minute discharge values. Presently, Stevens, Inc. type A/F records and OmniData loggers are in use. Tharp's and Log sites are fitted with Parshall flumes that provide direct stage-discharge relationships, which were established by USGS/WRD staff. Discharge rating curves were developed for the East Fork streams using tracer methods (Kilpatrick and Cobb 1985). Two additional Parshall flumes will be installed in the newly selected catchments, and Campbell data loggers and Druck pressure transducers will be installed to monitor flow.

Monitoring erosion and sediment transport is labor-intensive and costly. To effectively conduct this type of project, sites must be established and equipped with proper instrumentation, and adequate personnel must be available to carry out field work. Because sediment flux is variable, it is difficult to apply observations from one watershed to another. For this reason, we have chosen to establish six sites.

Data Evaluation

All field visits will be documented in "write in the rain" notebooks. A photocopy of the notebooks will be kept on file at the Sequoia-Kings Canyon Field Station. Permanent data sets will be developed to organize all aspects of data collection using MS Access97.

All suspended sediment analysis will occur in the Southern Sierra Water Laboratory. Samples will be filtered, weighed, dried and reweighed to determine the suspended sediment concentration (mg/L). Relationships between sediment and discharge, and sediment and turbidity will be developed using standard linear regression techniques. Seasonal relationships will be developed to evaluate overall patterns of sediment transport. More detailed relationships will be developed using the rising and

falling limbs of individual storm hydrographs. Sediment core samples will be sent to the Salinas field station for particle size analysis. Samples will be dried, sieved and analyzed.

Hillslope erosion will be evaluated by calculating the volume of soil removed from a given length of hillside (m^3/m). Individual plots will be used to evaluate variations in soil movement within a given slope range across all study sites, as well as overall soil movement for all slopes within a given catchment.

Discharge values will be calculated using the specific rating curve for each study stream. Total annual runoff from each study site will be determined using the total discharge (Q), and catchment area (A) ($[Qm^3/Am^2]*1000mm$). Total runoff will be correlated with hillslope erosion to evaluate what kind of relationships exist. The ratio of post-fire runoff to precipitation will also be determined and compared with prefire ratios. Changes in total runoff following fire are expected.

Precipitation pattern and type will be evaluated on an annual basis and by storm to determine how overall climate patterns versus specific storm patterns affect sediment transport and hillslope erosion. Data collected from non-USGS agencies (NPS and COE) will be requested at the end of each water year, and stored on the program computer in the Southern Sierra Water Laboratory.

Table 2. Monitoring and Data Collection

Questions to be Evaluated	Monitoring parameters & Data collection approach	Data Evaluation Approach	Comments/ Data Priority
How do topography and geomorphology influence sediment transport and hillslope erosion in small catchments following fire?	Automated samplers to collect suspended sediment. Survey pools to measure changes in sediment storage. Pebble counts to determine particle size in pools. Erosion bridges to evaluate hillslope erosion following fire.	Regress suspended sediment on discharge and turbidity by event and season. Evaluate sediment storage capacity and particle size in pools. Determine volume of sediment removed in the study catchments	Sampling storm events will be a high priority to capture sediment pulses.
How do post-fire precipitation patterns affect hillslope erosion and sediment movement in small catchments?	Meteorology stations, co-located near study sites, record hourly weather data. Survey pools to measure changes in sediment storage. Erosion bridges to evaluate hillslope erosion following fire.	Determine if patterns exist between post-fire precipitation, erosion and sediment storage.	
How does the timing of fire (late vs early season burning) affect sediment transport?	Fuel loads calculated using Brown's transects. Erosion bridges to evaluate hillslope erosion following fire. Survey pools to measure changes in sediment storage.	Calculate volume of litter & duff consumed. Review fire behavior for possible correlations with erosion and sediment storage.	

Progress Reports and Databases

- ◆ Quarterly and Annual progress reports will be prepared and presented to USGS/BRD and CalFed by February of each year.
- ◆ Additions to SEKI Field Station watershed database, which presently includes precipitation and stream chemistry, precipitation depth, stream discharge, and climate records dating back to 1982.

◆ Publications

The effects of fire on hillslope erosion in Southern Sierran mixed-conifer catchments. At least one peer-reviewed publication will compare fire effects on hillslope erosion in mixed-conifer catchments. A comparison of topography and soils in the study catchments will be evaluated. The effects of antecedent precipitation patterns will also be addressed. Likely journals include *Biogeochemistry*, *Can. J For. Res.*, *Ecology*, *Wat. Resour. Res.*

The effects of fire on small catchments (≤ 100 ha). At least one peer-reviewed publication will evaluate fire effects on small catchments, addressing the following questions: (1) What are the magnitudes of suspend transport and hydrologic responses in small catchments? (2) How is post-fire recovery influenced by catchment size? (3) How do large-scale prescribed fire effects compare with the well-documented wildfire effects observed in Yellowstone? Likely journals include *Biogeochemistry*, *Can. J For. Res.*, *Ecology*, *Tall Timbers*, *Eco. Appl.*

The effects of fire along an elevational gradient in the East Fork Kaweah drainage. At least one paper will focus on differences in sediment transport and hillslope erosion following fire in two catchments (Trauger's and Deadwood) with different vegetation types (chaparral and mixed-conifer). Likely journals include *For. Eco. Mgmt*, *Can. J For. Res.*, *Ecology*, *Eco. Appl.*

With outside collaborators, other publications regarding fire effects on soils, stream chemistry and aquatic macroinvertebrates are likely.

Local Involvement

Our primary clients for this project will be CalFed, DOI and USFS managers and policy makers in the Sierra Nevada, to whom we will supply specific information to guide management decisions and tools to help estimate the consequences of different management actions. Additionally, we will supply the broader scientific community with information relevant to understanding the effects of interacting stressors, both natural and anthropogenic, on ecosystems.

This project will be conducted in Sequoia National Park. The Sequoia-Kings Canyon Field Station has a multi-decadal history of strong and successful collaboration with the Park. A Memorandum of Understanding (MOU) is presently in place and promises future collaboration. Because of the downstream impacts of sediment transport, additional collaboration is being sought with the U.S. Army Corp of Engineers, the administrator of Lake Kaweah.

Cost

Capitol costs for this project include purchasing equipment to construct and operate the study sites. The project will be managed by the Sequoia-Kings Canyon Field Station Leader (8% per year). This time will be spent managing the budget, reviewing and finalizing quarterly and annual reports for CalFed, and reviewing draft publications. The daily operations will be managed by a Sequoia-Kings Canyon Field Station Ecologist, who presently oversees the Watershed Program. Periodic consulting with a Hydrologist and Statistician will be necessary. The majority of the field and lab work will be conducted by Biological Technicians that will be hired through USGS and/or Sequoia National Park. The project will require at least one year round technician (term position). Additional seasonal help will be necessary to meet the needs of sample multiple stations. The sediment cores will be shipped to another USGS lab for analysis. An additional cost to the project is the Western Ecological Research Center (WERC) charge (16%). WERC is the parent office of the Sequoia-Kings Canyon Field Station. At least one vehicle will be required to meet the demands of year round sampling. Two vehicles may be necessary during periods of intense sampling.

Table 3 summaries the budget expenses by task. The service contract section has been omitted as this project will not be using additional contracts to complete the work. Quarterly expenses are summarized in table 4.

Cost-Sharing

Much of the overhead typically attributed to a project will be covered by the Sequoia-Kings Canyon Field Station and Sequoia National Park, which provide office space, computers and support, phones, furniture, etc. Other potential cost sharing includes vehicles and personnel. The SEKI watershed program has a committed vehicle that would be available to this project on a cost share basis. Field staff from the watershed program may be available to assist with sediment field work. This would benefit both projects because intensive sampling times would be covered and technicians could assist with other SEKI research projects during slow times. By guaranteeing full time employment (by working on several projects) we are more likely to attract talented technicians.

Table 3. Budget breakdown by task for project beginning Oct. 1999 and ending Sept 2002. Salaries reflect cost-of-living increases.

Task	Direct Labor Hours	Direct Salary & Benefits	Material & Acquisition Costs	Misc. & Other Direct Costs	Overhead & Indirect Costs	Total Cost
Project Mgmt	GS-14/10 500	\$26,6000		\$2,000 - Travel	\$4,576 - WERC (16%)	\$33,176
PHASE I						
Task 1a	GS-05 240 GS-09 40 GS-12 30 Total 310	\$ 2,786 \$ 838 \$ 911 Tot \$ 4,536	\$200 - field equipment (maps, compass, etc.)	\$ 450 - Hydrologist Travel \$ 180 - Vehicle	\$ 858 - WERC (16%)	\$ 6,224
Task 1b	GS-05 320 GS-09 40 Total 360	\$ 3,715 \$ 838 Tot \$ 4,553		\$ 180 - Vehicle	\$ 757 - WERC (16%)	\$ 5,491
Task 1c	GS-05 1280 GS-09 120 GS-12 40 Total 1440	\$14,861 \$ 2,514 \$ 1,215 Tot \$18,590	\$6,400 - Parshall Flumes (2) \$ 300 - Const. Materials \$ 600 - Sampler housing (6)	\$ 450 - Hydrologist Travel \$ 720 - Vehicle \$ 500 - Material Transport	\$4,410 - WERC (16%)	\$31,969
Task 1d	GS-05 320 GS-09 40 Total 360	\$ 3,715 \$ 838 Tot \$4,553	\$7,800 - Data loggers (6) \$2,800 - Polycorder (2) \$1,200 - Transducers (4) \$ 500 - Misc	\$ 180 - Vehicle	\$2,725 - WERC (16%)	\$19,759
Task 1e	GS-05 320 GS-09 40 Total 360	\$ 3,715 \$ 838 Tot \$4,553	\$10,000 - Automated Sampler (4) \$ 3,000 - Turbidity Sensor (3) \$ 900 - DH-48 sampler (3) \$ 1,000 - Misc (tubing etc.)	\$ 180 - Vehicle	\$3,141 - WERC (16%)	\$22,775

Table 3. Continued.

Task	Direct Labor Hours	Direct Salary & Benefits	Material & Acquisition Costs	Misc. & Other Direct Costs	Overhead & Indirect Costs	Total Cost
PHASE 2						
Task 2a	GS-05 7500 GS-09 180 Total 7680	\$87,075 <u>\$ 3,771</u> Tot \$90,846		\$ 16,200 - Vehicle \$ 1,000 - Equipment service & repair	\$17,287 - WERC (16%)	\$125,333
Task 2b	GS-05 240 GS-09 120 Total 360	\$ 2,786 <u>\$ 2,514</u> Tot \$ 5,300	\$ 500 - Materials	\$ 720 - Vehicle \$ 200 - Equipment service & repair	\$ 1,075 - WERC (16%)	\$ 7,796
Task 2c	GS-05 2160 GS-09 180 Total 2340	\$25,078 <u>\$ 3,771</u> Tot \$28,849	\$ 500 - Materials	\$ 3,240 - Vehicle \$ 200 - Equipment service & repair	\$ 5,246 - WERC (16%)	\$ 38,035
Task 2d	GS-09 1040	\$21,788	\$1,000 - Copy/ Misc. office costs	\$ 500 - Software upgrades \$2,000 - Travel meetings/ conferences	\$ 4,046 - WERC (16%)	\$ 29,334
PHASE 3						
Task 3a	GS-09 200	\$ 4,190		\$5,800 - Sample analysis \$ 500 - Shipping	\$ 1,678 - WERC (16%)	\$ 12,168
Task 3b	GS-09 800 GS-12 240 Total 1040	\$16,760 <u>\$ 7,289</u> Tot \$24,049		\$ 500 - Statistical Consulting \$1,000 - Travel meetings/ conferences	\$ 4,088 - WERC (16%)	\$ 29,637
Task 3c	GS-09 800 GS-12 240 Total 1200	\$16,760 <u>\$ 7,289</u> Tot \$24,049	\$1,000 - Copy & publication charges		\$ 4,008 - WERC (16%)	\$ 29,057
Total Funds Requested						\$390,752

Table 4. Quarterly budget expenses.

Task	Quarterly Budget Oct-Dec 99	Quarterly Budget Jan-Mar 00	Quarterly Budget Apr-Jun 00	Quarterly Budget Jul-Sep 00	Quarterly Budget Oct-Dec 00	Quarterly Budget Jan-Mar 01	Quarterly Budget Apr-Jun 01	Quarterly Budget Jul-Sep 01
Project Mgmt	\$ 2,600	\$ 2,600	\$ 2,600	\$ 2,600	\$ 2,680	\$ 2,680	\$ 2,680	\$ 3,180
PHASE 1								
Task 1a	\$ 6,224							
Task 1b	\$ 2,675	\$ 2,816						
Task 1c	\$31,969							
Task 1d	\$19,759							
Task 1e	\$16,333	\$ 6,442						
PHASE 2								
Task 2a	\$12,208	\$12,208	\$12,208	\$12,859	\$12,508	\$12,508	\$12,508	\$13,110
Task 2b	\$ 1,546		\$ 1,546		\$ 1,583		\$ 1,583	
Task 2c	\$ 4,678		\$ 4,678	\$ 4,678	\$4,754		\$4,754	\$4,754
Task 2d	\$ 2,916	\$ 2,916	\$ 2,916	\$ 2,917	\$ 2,977	\$ 2,977	\$ 2,977	\$ 2,977
PHASE 3								
Task 3a	\$ 2,417		\$ 2,417		\$ 2,440		\$ 2,440	
Task 3b							\$ 5,838	\$ 5,838
Task 3c								

Table 4. Continued.

Task	Quarterly Budget Oct-Dec 02	Quarterly Budget Jan-Mar 02	Quarterly Budget Apr-Jun 02	Quarterly Budget Jul-Sep 02	Total Cost
Project Mgmt	\$ 2,760	\$ 2,760	\$ 2,760	\$ 3,276	\$ 33,176
PHASE 1					
Task 1a					\$ 6,224
Task 1b					\$ 5,491
Task 1c					\$ 31,969
Task 1d					\$ 19,759
Task 1e					\$ 22,775
PHASE 2					
Task 2a	\$12,608	\$12,608			\$125,333
Task 2b	\$ 1,539				\$ 7,796
Task 2c	\$ 4,868	\$ 4,868			\$ 38,035
Task 2d	\$ 2,880	\$ 2,880			\$ 29,334
PHASE 3					
Task 3a	\$ 2,454				\$ 12,168
Task 3b	\$ 5,987	\$ 5,987	\$ 5,987		\$ 29,637
Task 3c	\$ 6,392	\$ 6,392	\$ 8,136	\$ 8,136	\$ 29,057
TOTAL					\$390,752

Applicant Qualifications

The project will be administered by the Sequoia and Kings Canyon Field Station Leader, Jon Keeley. He will oversee the budget, and review and finalize reports and publications. Claudette Moore, will coordinate field work and data analysis. Biological technicians will be hired through USGS or NPS to complete field and lab work. These positions may be shared with ongoing BRD watershed research projects to provide adequate coverage to both projects during periods of intensive sampling. In addition, we will consult with USGS and UC Santa Barbara hydrologists during Phase I (site selection and setup) and Phase III (final data analysis).

Jon E. Keeley

Education: Ph.D. (Botany) University of Georgia, Athens, 1977
M.S. (Biology) San Diego State University, 1973
B.S. (Biology) San Diego State University, 1971

Positions: USGS Biological Resources Division, Station Leader, 1998–
National Science Foundation, Program Director 1997–1998
Occidental College, Professor 1988–1998
Department Chair 1982–1988,
Assist/Assoc Professor 1977–1988,
University of Cape Town, Visiting Professor 1990

Awards: Guggenheim Fellow, 1985–1986
Sterling Award for Outstanding Teaching, 1985
Fellow, Southern California Academy of Sciences, 1994
Honorary Lifetime Member, California Botanical Society, 1998

Recent Research Grants:

National Science Foundation, Ecology Program, Community Biodiversity and Wildfires,
1994–1995 (\$30,000)
U.S. National Park Service, Postfire Succession and Emergency Rehabilitation Studies,
1994–1995 (\$45,000; with Dr. Tony Orme, UCLA)
Metropolitan Water District, Comparative Studies of Ecological Impacts of Wildfires
on Vegetation Recovery, 1995–99 (\$119,000)
Metropolitan Transit Authority, Impact of Groundwater Drainage, 1997 (\$40,000)

Recent Research Publications:

- Keeley, J.E. and C.C. Swift. 1994. Biodiversity and ecosystem function in mediterranean-climate California, pp. 121-183. In G. Davis and D.M. Richardson (eds), *Biodiversity and Function in Mediterranean-type ecosystems*. Springer-Verlag, N.Y.
- Keeley, J.E., M. Carrington, and S. Trnka. 1995. Overview of management issues raised by the 1993 wildfires in 1993 wildfires in southern California, pp. 83-89. In J.E. Keeley and T. Scott (eds), *Brushfires in California: Ecology and Resource Management*. International Assoc. Wildland Fire, Fairfield, Washington.
- Keeley, J.E. 1996. Postfire vegetation recovery in the Santa Monica Mountains under two alternative management programs. *Bulletin of the Southern California Academy of Sciences* 95:103-119.
- Keeley, J.E. and C.J. Fotheringham. 1997. Trace gas emissions in smoke-induced germination. *Science* 276:1248-1250.
- Keeley, J.E. 1998. Postfire ecosystem recovery and management: The October 1993 large fire episode in California, pp. 69-90. In J.M. Moreno (ed), *Large Forest Fires*. Backhuys Publishers, Leiden, The Netherlands.

Claudette L. Moore**Education:**

- M.S. Watershed Management, University of Washington, Seattle, WA 1993
 B.S. Environmental Biology, Humboldt State University, Arcata, CA 1985

Experience:

- 1998-present Ecologist, Watershed Research Program, USGS/BRD
 1996-1998 Lead Biological Technician, Watershed Research Program, USGS/BRD
 1993-1996 Lead Biological Technician, Fire Effects Monitoring, National Park Service
 1992-1993 High School Science Teacher, Big Water, UT
 1990-1992 Research Assistant, Environmental Engineering Dept., U. of Washington, Seattle, WA

References

- Barber, T.J. 1996 Hetten and Tompkins paired watershed study. In: *Watershed Mgmt Council Networker*. Vol 6 No. 5. Humboldt State Univ., Arcata, CA 5p.
- Brown, J.K., R.D. Oberhue, and D.M. Johnston. 1982. *Inventorying surface fuels and biomass in the interior west*. USDA Forest Service. Intermountain Forest and Range Experiment Station. Gen. Tech. Report INT-129. 48p.
- Caprio, A. C. 1996. *Research, Inventory and Monitoring: Mineral King Risk Reduction Project*. Annual Report to Sequoia and Kings Canyon National Parks, Three Rivers, CA 75 pp.
- Chan, I.A. 1998. *Aquatic Macroinvertebrates of small streams in the Mineral King Region of Sequoia National Park: Baseline communities and response to prescribed fire*. Thesis. University of California, Davis. 111p.
- Chorover, J., P.M. Vitousek, D.A. Everson, A.M. Esperanza, and D. Turner. 1994. Solution chemistry profiles of mixed-conifer forests before and after fire. *Biogeochemistry* 26:115-144.
- Edwards, T.K. and G.D. Glysson. 1988. *Field methods for measurement of fluvial sediment*. U.S. Geological Survey Open-File Report 86-531, Reston, VA 118p.
- Goldman, C. R. and A. J. Horne. 1983. *Limnology*. McGraw-Hill, Inc., New York, NY.
- Herrmann, R. and R. Stottlemeyer. 1991. Long-term monitoring for environmental change in U.S. national parks a watershed approach. *Environmental Monitoring and Assessment* 17:5165.
- Kilpatrick, F.A. and E.D. Cobb. 1985. *Measurement of discharge using tracers*. Techniques of Water Resources Investigations, Book 3, Chapter A16. U.S. Geological Survey.
- Lewis J. and Eads R. 1996. Turbidity-controlled suspended sediment sampling. In: *Watershed Mgmt Council Networker*. Vol 6 No. 5. Humboldt State Univ., Arcata, CA 4p.
- McKelvey, K.S., C.N. Skinner, C-r. Chang, D.C. Erman, S.J. Husari, D.J. Parsons, J.W. van Wagtendonk, and C.P. Weatherspoon. 1996. An overview of fire in the Sierra Nevada, pp. 1033-1040. In *Sierra Nevada Ecosystem Project Final Report to Congress, Volume II*. Centers for Water and Wildland Resources, University of California, Davis.
- Menning, K., D.C. Erman, K.N. Johnson, and J. Sessions. 1996. Modeling aquatic and riparian systems, assessing cumulative watershed effects, and limiting watershed disturbance, pp. 33-51. In *Sierra Nevada Ecosystem Project Final Report to Congress, Volume IV*. Centers for Water and Wildland Resources, University of California, Davis.

- Minshall, G. W. and J. T. Brock. 1991. Observed and anticipated effects of forest fire on Yellowstone stream ecosystems. pp. 123-135. In: Keiter, R. B. and M. S. Boyce (eds.) *The Greater Yellowstone Ecosystem Redefining America's Wilderness Heritage*, Yale University Press, New Haven, Connecticut.
- Minshall, G. W. and C. T. Robinson. 1992. *The effects of the 1988 wildfires on stream systems of Yellowstone National Park*. Idaho State University, Stream Ecology Center. 48 pp.
- Moyle, P.B. and T. Light. 1996. Fish invasions in California: Do abiotic factors determine success? *Ecology* 77:1666-1670.
- Moyle, P.B. and P.J. Randall. 1996. Biotic integrity of watersheds, pp. 975-986. In *Sierra Nevada Ecosystem Project Final Report to Congress, Volume II*. Centers for Water and Wildland Resources, University of California, Davis.
- Parsons, D.J. and D.W. Graber. 1985. Integrated watershed research undertaken at Sequoia National Park. *Park Science* 5(2):22-24.
- Robichaud P. R. 1994. A comparison of surface runoff and sediment yields from low- and high- severity site prep burns. *Wat. Resour. Bull.* 30: 27-34.
- Silde, R. C. 1988. Bed load transport regime of small forest stream. *Wat. Resour. Res.* 24:207-218.
- Smith, J.L. 1974. Hydrology of warm snowpacks and their effects upon water delivery...some new concepts. In *Advanced concepts and techniques in the study of snow and ice resources*. National Academy of Sciences, Washington, D.C. 14p.
- SNEP. 1996. Sierra Nevada Ecosystem Project Final Report to Congress, Volume I. Centers for Water and Wildland Resources, University of California, Davis.
- Swanson, F.J. 1981. Fire and geomorphic processes, pp. 401-420. In: H.A. Mooney, T.M. Bonnicksen, N.L. Christensen, J. Lotan, and W.A. Reiners (eds) *Fire regimes and ecosystem properties*. USDA Forest Service, General Technical Report WO-26.
- Tiedemann, A. R., C. E. Conrad, J. H. Dieterich, J. W. Hornbeck, W. F. Megahan, L. A. Viereck, and D. D. Wade. 1979. *Effects of fire on water: a state-of-the-art knowledge review*. US Forest Service General Technical Report WO-10 Washington, DC.
- Williams, M.R. and J.M. Melack. 1997. Atmospheric deposition, mass balances, and processes regulating streamwater solute concentrations in mixed-conifer catchments of the Sierra Nevada, California. *Biogeochemistry* 37:111-144.

Attachment E
Terms and Conditions for Federal (Department of Interior) Funds

U.S. Department of the Interior

**Certifications Regarding Debarment, Suspension and
Other Responsibility Matters, Drug-Free Workplace
Requirements and Lobbying**

Persons signing this form should refer to the regulations referenced below for complete instructions:

Certification Regarding Debarment, Suspension, and Other Responsibility Matters - Primary Covered Transactions - The prospective primary participant further agrees by submitting this proposal that it will include the clause titled, "Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transaction," provided by the department or agency entering into this covered transaction, without modification, in all lower tier covered transactions and in all solicitations for lower tier covered transactions. See below for language to be used; use this form for certification and sign; or use Department of the Interior Form 1854 (DI-1954). (See Appendix A of Subpart D of 43 CFR Part 12.)

Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transactions - (See Appendix B of Subpart D of 43 CFR Part 12.)

Certification Regarding Drug-Free Workplace Requirements - Alternate I. (Grantees Other Than Individuals) and Alternate II. (Grantees Who are Individuals) - (See Appendix C of Subpart D of 43 CFR Part 12)

Signature on this form provides for compliance with certification requirements under 43 CFR Parts 12 and 18. The certifications shall be treated as a material representation of fact upon which reliance will be placed when the Department of the Interior determines to award the covered transaction, grant, cooperative agreement or loan.

**PART A: Certification Regarding Debarment, Suspension, and Other Responsibility Matters -
Primary Covered Transactions**

CHECK IF THIS CERTIFICATION IS FOR A PRIMARY COVERED TRANSACTION AND IS APPLICABLE.

- (1) The prospective primary participant certifies to the best of its knowledge and belief, that it and its principals:
 - (a) Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency;
 - (b) Have not within a three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;
 - (c) Are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State or local) with commission of any of the offenses enumerated in paragraph (1)(b) of this certification; and
 - (d) Have not within a three-year period preceding this application/proposal had one or more public transactions (Federal, State or local) terminated for cause or default.
- (2) Where the prospective primary participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

**PART B: Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion -
Lower Tier Covered Transactions**

CHECK IF THIS CERTIFICATION IS FOR A LOWER TIER COVERED TRANSACTION AND IS APPLICABLE.

- (1) The prospective lower tier participant certifies, by submission of this proposal, that neither it nor its principals is presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participation in this transaction by any Federal department or agency.
- (2) Where the prospective lower tier participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

DI-2418
March 1995
(This form covers Regulations DI-1853, DI-1854,
DI-1955, DI-1956 and DI-1983)

PART C: Certification Regarding Drug-Free Workplace Requirements

CHECK ☒ IF THIS CERTIFICATION IS FOR AN APPLICANT WHO IS NOT AN INDIVIDUAL.

Alternate I. (Grantees Other Than Individuals)

A. The grantee certifies that it will or continue to provide a drug-free workplace by:

- (a) Publishing a statement notifying employees that the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance is prohibited in the grantee's workplace and specifying the actions that will be taken against employees for violation of such prohibition;
- (b) Establishing an ongoing drug-free awareness program to inform employees about--
 - (1) The dangers of drug abuse in the workplace;
 - (2) The grantee's policy of maintaining a drug-free workplace;
 - (3) Any available drug counseling, rehabilitation, and employee assistance programs; and
 - (4) The penalties that may be imposed upon employees for drug abuse violations occurring in the workplace;
- (c) Making it a requirement that each employee to be engaged in the performance of the grant be given a copy of the statement required by paragraph (a);
- (d) Notifying the employee in the statement required by paragraph (a) that, as a condition of employment under the grant, the employee will --
 - (1) Abide by the terms of the statement; and
 - (2) Notify the employer in writing of his or her conviction for a violation of a criminal drug statute occurring in the workplace no later than five calendar days after such conviction;
- (e) Notifying the agency in writing, within ten calendar days after receiving notice under subparagraph (d)(2) from an employee or otherwise receiving actual notice of such conviction. Employers of convicted employees must provide notice, including position title, to every grant officer on whose grant activity the convicted employee was working, unless the Federal agency has designated a central point for the receipt of such notices. Notice shall include the identification numbers(s) of each affected grant;
- (f) Taking one of the following actions, within 30 calendar days of receiving notice under subparagraph (d)(2), with respect to any employee who is so convicted --
 - (1) Taking appropriate personnel action against such an employee, up to and including termination, consistent with the requirements of the Rehabilitation Act of 1973, as amended; or
 - (2) Requiring such employee to participate satisfactorily in a drug abuse assistance or rehabilitation program approved for such purposes by a Federal, State, or local health, law enforcement, or other appropriate agency;
- (g) Making a good faith effort to continue to maintain a drug-free workplace through implementation of paragraphs (a) (b), (c), (d), (e) and (f).

B. The grantee may insert in the space provided below the site(s) for the performance of work done in connection with the specific grant:

Place of Performance (Street address, city, county, state, zip code)

U.S.G.S./Biological Resources Division

Western Ecological Research Center

Sequoia and Kings Canyon Field Station

47050 Generals Highway

Three Rivers, CA 93271

Check ☐ if there are workplaces on file that are not identified here.

PART D: Certification Regarding Drug-Free Workplace Requirements

CHECK ☐ IF THIS CERTIFICATION IS FOR AN APPLICANT WHO IS AN INDIVIDUAL.

Alternate II. (Grantees Who Are Individuals)

- (a) The grantee certifies that, as a condition of the grant, he or she will not engage in the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance in conducting any activity with the grant;
- (b) If convicted of a criminal drug offense resulting from a violation occurring during the conduct of any grant activity, he or she will report the conviction, in writing, within 10 calendar days of the conviction, to the grant officer or other designee, unless the Federal agency designates a central point for the receipt of such notices. When notice is made to such a central point, it shall include the identification number(s) of each affected grant.

PART E: Certification Regarding Lobbying
Certification for Contracts, Grants, Loans, and Cooperative Agreements

CHECK IF CERTIFICATION IS FOR THE AWARD OF ANY OF THE FOLLOWING AND
THE AMOUNT EXCEEDS \$100,000: A FEDERAL GRANT OR COOPERATIVE AGREEMENT,
SUBCONTRACT, OR SUBGRANT UNDER THE GRANT OR COOPERATIVE AGREEMENT.

CHECK IF CERTIFICATION IS FOR THE AWARD OF A FEDERAL
LOAN EXCEEDING THE AMOUNT OF \$150,000, OR A SUBGRANT OR
SUBCONTRACT EXCEEDING \$100,000, UNDER THE LOAN.

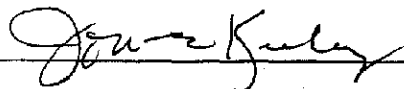
The undersigned certifies, to the best of his or her knowledge and belief, that:

- (1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, and officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
- (2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.
- (3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure.

As the authorized certifying official, I hereby certify that the above specified certifications are true.

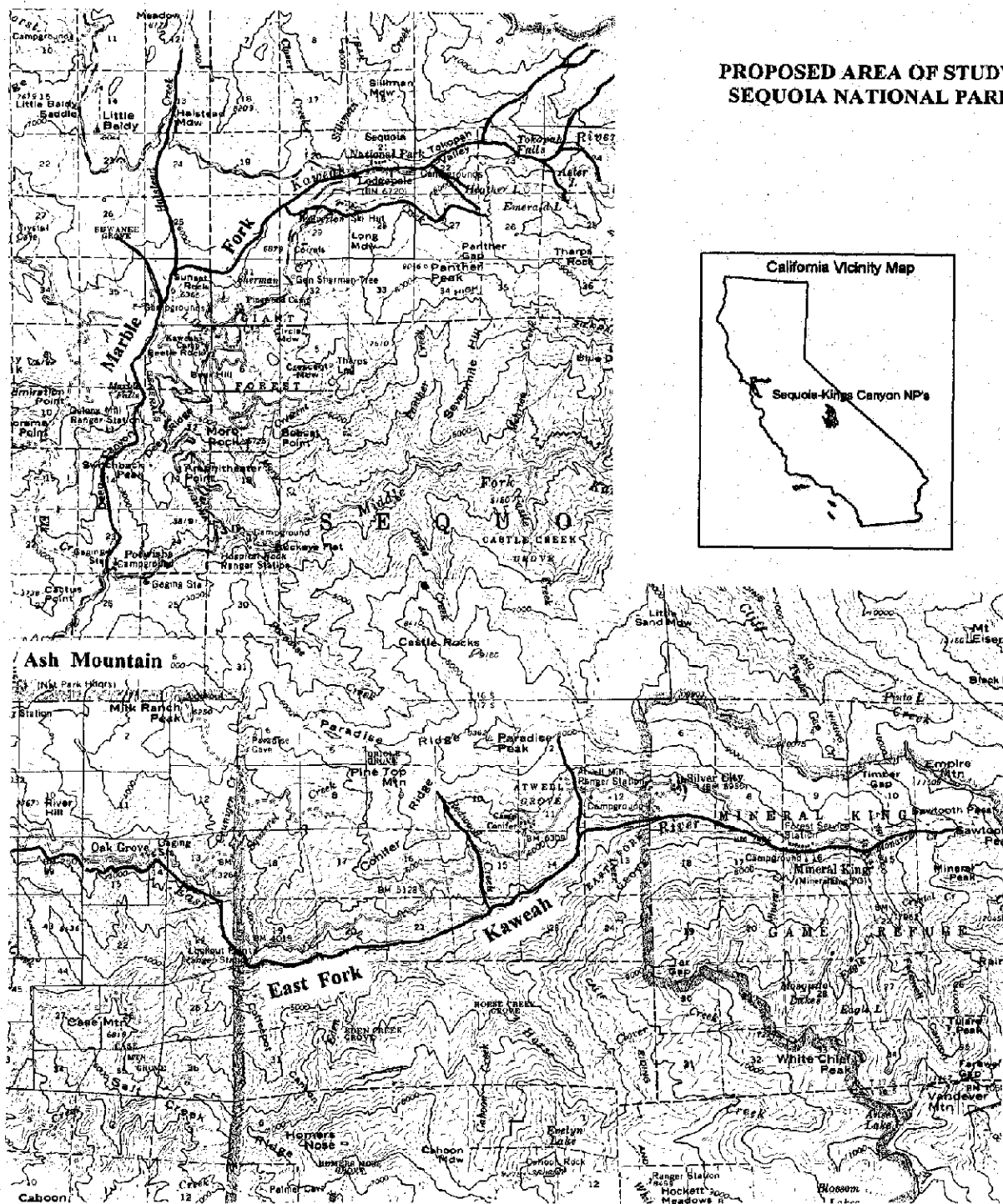
SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL



TYPED NAME AND TITLE Jon E. Keeley, Research Ecologist

DATE April 13, 1999

PROPOSED AREA OF STUDY SEQUOIA NATIONAL PARK



Scale 1:125,000

Figure 1. Map of proposed study area in Sequoia National Park. Copied from USGS map of Sequoia and Kings Canyon National Parks.